

Citation:

Mattes RD, Campbell WW. Effects of food form and timing of ingestion on appetite and energy intake in lean young adults and in young adults with obesity. J Am Diet Assoc. 2009 Mar;109(3):430-7.

PubMed ID: [19248858](#)

Study Design:

Randomized crossover study

Class:

A - [Click here](#) for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

The purpose of this study was to assess the effects of food form (ie, solid, semisolid, and beverage forms) and intake pattern (ie, with a meal or as a snack) on appetite and energy intake in lean individuals and individuals with obesity.

Inclusion Criteria:

- Men and women between 18 and 60 years
- BMI between 18 and 25 ("lean") or 30 and 35 ("obese")
- Less than 5kg weight change in the last 3 months (stable weight)
- Self-reported good health
- No appetite and weight loss medication
- Stable physical activity levels (no deviation from a pattern of more than one 30 minute session/week)
- Low dietary inhibition (<14 on the Three Factor Eating Questionnaire)
- Regular eating patterns (e.g., at least 3 meals per day, including breakfast)
- Participants signed an informed consent form

Exclusion Criteria:

- Men and women between <18 and >60 years
- BMI between <18, between 25-30, and >35
- Greater than 5kg weight change in the last 3 months (unstable weight)
- Not in self-reported good health
- Taking or terminating appetite and weight loss medication
- Unstable physical activity levels (deviation from a pattern of more than one 30 minute session/week)
- Dietary inhibition (>14 on the Three Factor Eating Questionnaire)
- Irregular eating patterns (meals and snacks)

Description of Study Protocol:

Recruitment

- Recruited through public advertisements
- Directed to an online screening questionnaire eliciting demographic, health, and diet information.
- Questionnaire was reviewed by research staff for participant eligibility.

Design

- Crossover design with six different treatments
 - Three treatments provided the beverage, semisolid, or solid supplement during a meal
 - Three treatments provided the beverage, semisolid, or solid supplement two hours after a meal
 - Each of the treatments provided either a beverage, semisolid, or solid supplement for a total of 6 different treatments
- Participants acted as their own controls
- 2 categories: Lean and Obese

Blinding used

Participants were informed of a different intent of the study so as not to alter their dietary intake.

Intervention

- During 6 trial days, participants reported to a testing facility 3 hours after consuming a breakfast that was customary for them.
- Diet recalls, finger prick blood samples to verify fasting blood glucose levels, and questionnaires about their food, mood, and appetite were completed.
- Each participant underwent 6 different treatments:
 - During three visits participants were given a fixed meal consisting of 25% of their estimated energy requirement.
 - One half of the energy was provided as liquid and one half as solids
 - At the end of each meal, each participants was provided with beverage, semisolid, or solid supplement to eat at that time
 - During three visits participants were given a fixed meal consisting of 25% of their estimated energy requirement.
 - One half of the energy was provided as liquid and one half as solids
 - Two hours after each meal, each participants was provided with beverage, semisolid, or solid supplement to eat at that time.
 - Diet records were kept for all 6 days of treatment
 - Before and after appetites were recorded on visual analog scales

Statistical Analysis

- Differences in group characteristics were assessed by t tests
- Treatment effects were measured by a mixed model, repeated measures analysis of variance
- Meal timing (eg, meal or snack) and food form (eg, solid, semisolid, or beverage) were treated as within-subject factors
- BMI was treated as a between-subjects factor

- The criteria for statistical significance was $P < 0.05$, two-tailed.

Data Collection Summary:

Timing of Measurements

- During three visits participants were given a fixed meal consisting of 25% of their estimated energy requirement. At the end of each meal, each participants was provided with beverage, semisolid, or solid supplement to eat at that time
- During three visits participants were given a fixed meal consisting of 25% of their estimated energy requirement. Two hours after each meal, each participants was provided with beverage, semisolid, or solid supplement to eat at that time.

Dependent Variables

- Variable 1: Appetite assessment as measured by visual analog scale
- Variable 2: Energy intake as measured by dietary recall and reviewed by a Registered Dietitian

Independent Variables

- Type of supplement ingested (liquid, semi-solid, or solid)
- Timing of supplement (during meal or 2 hours after the meal)

Control Variables

- Diet recalls, finger prick blood samples to verify fasting blood glucose levels, and questionnaires about their food, mood, and appetite were completed.

Description of Actual Data Sample:

Initial N: Not listed

Attrition (final N): 20 Lean and 20 obese individuals

Age: Lean group: 21.6 ± 2.1 years, Obese group: 25.6 ± 5.9 years

Ethnicity: Not described

Other relevant demographics: 10 men and women in each group

Anthropometrics: Lean group: 22.6 ± 1.8 ; Obese group: 32.3 ± 1.5

Location: Purdue University, West Lafayette, IN

Summary of Results:

Key Findings for Hunger Ratings:

- The ingestion of isoenergetic loads of juice, applesauce, or whole fruit led to significantly different postingestive reductions of hunger when included **in the meal** ($P = 0.025$)

- Thirty minutes following the meal, hunger was significantly lower following whole fruit ingestion compared to the juice and applesauce. From 60 to 90 minutes after the meal, hunger was significantly lower following whole fruit ingestion compared to the juice.
- The ingestion of isoenergetic loads of juice, applesauce, or whole fruit led to significantly different postingestive reductions of hunger when eaten as a snack **2 hours after the meal** ($P<0.001$)
 - Thirty minutes following the snack and 60 minutes following the snack, hunger was significantly lower following whole fruit ingestion compared to the juice and applesauce. Ninety minutes after the snack, hunger was significantly lower following whole fruit ingestion compared to the juice. One hundred and twenty minutes after the snack, hunger was significantly lower following applesauce ingestion compared to the juice.

Key Findings for Fullness Ratings:

- The ingestion of isoenergetic loads of juice, applesauce, or whole fruit led to significantly different postingestive fullness ratings when included **in the meal** ($P=0.026$)
 - 30 and 60 minutes following ingestion, fullness was significantly lower for the juice compared to the applesauce or whole fruit, and the juice was also less than the whole fruit at 90 minutes and the sauce at 120 minutes.
- The ingestion of isoenergetic loads of juice, applesauce, or whole fruit led to significantly different postingestive fullness ratings when eaten as a snack **2 hours after the meal** ($P=0.020$)
 - 30, 60, and 120 minutes after ingestion, fullness ratings were lower for the juice compared to the whole fruit and sauce and lower than ratings after whole fruit only at 90 minutes.

Other key findings:

- Eating an apple during the meal produced a smaller reduction in hunger than eating an apple 2 hours after the meal as a snack ($P=0.028$)
- There was no difference between BMI groups.
- There were no hunger or fullness differences between lean and obese subjects following ingestion of any of the foods, consumed during the meal or as a snack to hours later.

Intermeal Interval (The next meal after the lunch or snack where >100 kcal was consumed)

- Hunger ratings at the time of the first eating occasion (>100 kcal) after lunch and snacks were similar regardless of load form and timing of load ingestion. None of the hunger ratings were significantly correlated with energy intake at that eating occasion.
- The time interval between ingestion of the experimental lunch and the first self-initiated eating event was shorter when the load was a beverage compared to the isoenergetic load of sauce or whole fruit. The difference between the juice and sauce treatments was significant ($P=0.011$) and approached significance for the juice vs whole fruit comparison ($P=0.085$).
- When the loads were consumed 2 hours after the meal, the difference between the juice and whole fruit was significant ($P=0.018$) and the comparison between the juice and sauce approached significance ($P=0.093$).
- The form of the food load had no significant effect on energy intake at the first eating occasion of >100 kcal or daily energy intake after ingestion of the experimental meal and the load whether consumed with the meal or 2 hours after

Author Conclusion:

The authors concluded that beverages consumed alone as an afternoon snack or when incorporated into a midday meal lead to comparable, weak appetitive effects. Stronger effects were noted with a solid form of the same food and intermediate effects were observed with a semisolid form. This suggests that energy-yielding beverage consumption poses a particular risk for promoting positive energy balance when consumed either as a snack or with a meal. However, these appetitive effects did not translate into differences in energy intake.

Reviewer Comments:

- *There was a limited description of demographic characteristics.*
- *Investigators/data collectors were not blinded to the interventions.*
- *Statistical analyses, although correct, were inadequately described.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

- | | | |
|----|---|-----|
| 1. | Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies) | Yes |
| 2. | Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about? | Yes |
| 3. | Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice? | Yes |
| 4. | Is the intervention or procedure feasible? (NA for some epidemiological studies) | Yes |

Validity Questions

- | | | |
|------|---|-----|
| 1. | Was the research question clearly stated? | Yes |
| 1.1. | Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified? | Yes |
| 1.2. | Was (were) the outcome(s) [dependent variable(s)] clearly indicated? | Yes |
| 1.3. | Were the target population and setting specified? | Yes |
| 2. | Was the selection of study subjects/patients free from bias? | Yes |

2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	No
2.4.	Were the subjects/patients a representative sample of the relevant population?	Yes
3.	Were study groups comparable?	Yes
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	N/A
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	Yes
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	N/A
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	Was method of handling withdrawals described?	N/A
4.1.	Were follow-up methods described and the same for all groups?	N/A
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	N/A
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	N/A
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	Was blinding used to prevent introduction of bias?	No

5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	No
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	???
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	N/A
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described?	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	N/A
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	Were outcomes clearly defined and the measurements valid and reliable?	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	No

7.7.	Were the measurements conducted consistently across groups?	Yes
8.	Was the statistical analysis appropriate for the study design and type of outcome indicators?	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	N/A
8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	No
9.	Are conclusions supported by results with biases and limitations taken into consideration?	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	Yes
10.	Is bias due to study's funding or sponsorship unlikely?	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes

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